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by

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by

George M. Kuznets[1] and George Harvey[2]

During 1949, 1950, and 1951, the California Crop and Livestock Reporting Service, a cooperative office of the California State Department of Agriculture and the Bureau of Agricultural Economics, U. S. Department of Agriculture, prepared and published special estimates of production of raisins in California. These estimates were based on information provided by specially designed samples drawn from a listing of raisin-type grape units located in the major producing counties of the state. Table 1 provides in summary form a schedule of the experimental surveys during the three seasons. It will be noted that four surveys were carried out each season, namely, a preharvest survey, two surveys during the harvesting period (hereafter referred to as within-season surveys) one week apart, and a final survey.[3] In each of the preharvest surveys, the operators of sample units were interviewed by specially hired and trained enumerators, who had a background of experience in the local grape industry. The final surveys were carried out by mail with personal interview follow-up of all nonrespondents. In 1949 and 1950, the within-season surveys were by mail only and in 1951 by interview of one-half of the total sample. The schedules employed in the 1951 surveys are shown in the Appendix. In addition to raisin production by main varieties, information was obtained from operators on bearing acreage in sample units and acreage harvested for production of raisins. In 1951, information was also obtained prior to harvest on acreage to be harvested for

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* The activities discussed herein were conducted under the general direction of G. A. Scott, State Statistician in charge of the Federal-State Crop and Livestock Reporting Service in California.

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[3] The following persons supervised the field work for these surveys: 1949, Irwin Rust, Extension Service, University of Hawaii; 1950, James H. Swedberg, Bureau of Agricultural Economics, Sacramento; 1951, Robert D. Parr, Bureau of Agricultural Economics, Sacramento.

TABLE 1

Schedule of Raisin Production Surveys, California 1949, 1950, and 1951

	Preharvest survey	First within-season survey	Second within-season survey	Final survey
		1949 Season (four-county sample)		
Field work	August 5-31	September 1[a]	September 8[a]	September 23[a]
Reference[b]	--	September 5	September 12	--
Closing date	--	September 12	September 19	October 11
Report date	Not issued	September 13	September 20	November 3
		1950 Season (seven-county sample)		
Field work	August 9-23	August 28[a]	September 5[a]	September 22[a]
Reference[b]	--	August 31	September 7	--
Closing date	August 23	September 4	September 11	October 13
Report date	Not issued	September 6	September 12	October 19
		1951 Season (seven-county sample)		
Field work	August 21-25	September 4-5	September 11-12	October 2-6[c]
Reference[b]	--	September 4	September 11	--
Closing date	August 25	September 5	September 12	October 6
Report date	August 29	September 7	September 14	October 10

a/ Mailing date.

b/ Date to which observations pertained.

c/ Interview follow-up; mailing date one week earlier.

raisins and expected total production of raisin grapes and, in the final survey, on tons of raisin-type grapes harvested for all uses. Funds for this work were made available jointly by the State Department of Agriculture and the Production and Marketing Administration under the Research and Marketing Act of 1946. Members of the staff of the Giannini Foundation of the University of California participated in the planning of these studies, the design of samples, and the analysis of data collected in the surveys.

The purpose of this report is to provide a description and appraisal of the procedures employed, with emphasis on the 1951 surveys. Particularly for descriptive material, this report has drawn freely on a memorandum regarding the several RMA projects on methods of estimating California raisin and grape crops prepared for administrative use in May, 1951.

Background Information

Of the total production of raisins in California, including both natural and bleached, over 90 per cent is made from Thompson Seedless variety grapes and most of the remainder from Muscat, Black Corinth (Zante currant), and Sultana varieties. In 1951, the bearing acreage of raisin grape varieties in California was 230,379 acres, of which the Thompson Seedless variety accounted for 187,474 or 81.4 per cent of the total. The other two major varieties, Muscat and Sultana, accounted only for 36,360 (15.8 per cent) and 4,043 (1.8 per cent) bearing acres, respectively. The remainder of the bearing acreage in 1951, 2,502 acres, included 2,414 acres of Zante currant. The seven counties of Fresno, Kern, Kings, Madera, Merced, Stanislaus, and Tulare, in which all but a few tons of the raisin crop is produced, account for 94.1 per cent of the total, and Fresno County alone for 57.0 per cent.

Slightly under 60 per cent of total fresh weight of raisin grapes sold during the five-year period, 1946-1950, was made into raisins. The other major outlet for raisin grapes is wine, brandy, or juice. This outlet accounted for almost 30 per cent of all sales during this period. Of greater relevance to the problem of efficient estimation of raisin production is the marked year-to-year variation in utilization of raisin grapes. During the years 1946, 1947, and 1948, total sales of raisin grapes varied only slightly. However, in 1946 raisins accounted for 47 per cent of total use; in 1947 this percentage jumped to 72; and in 1948 it dropped to 55. The possibility of abrupt shifts in utilization apart from annual variation in the yield of raisin grapes complicates the problem of designing an efficient sample for the estimation of raisin production.

Grapes for natural raisins are harvested from late August to late September. Bunches are removed from the vine and placed on paper or wooden drying trays (2' x 3') which are laid between vine rows. The average fresh weight of grapes laid on the drying trays is about 22 pounds. The grapes are left in the sun to dry for a few weeks, losing about 75 per cent in weight. After rolling or stacking trays, raisins are placed in sweatboxes or field boxes and left a short time in the boxes to cure. Following this, raisins may be stored for an indefinite period of time on the farm or delivered immediately to a handler for cleaning, sorting, and packing. In 1950, about 40 per cent of the natural crop was delivered by November 1, 60 per cent by December 1, 71 per cent by January 1, 1951, and 93 per cent by March 1, 1951. Deliveries of the 1951 natural crop apparently were somewhat earlier, with about 38 per cent delivered by November 1, 74 per cent by December 1, 88 per cent by January 1, 1952, and about 96 per cent by March 1, 1952.

In addition to the sun-dried or natural raisins, other raisin types which require much less drying time are made by dipping the grapes in a caustic solution to break the skin slightly, and then drying them in the open or artificially by the use of dehydrators. The types most commonly made in California are Golden Bleached, Sulfur Bleached, and Soda-Dipped raisins, and these together, from 1946 to 1950, amounted to about 8 per cent of all raisins made. All bleached types of raisins are made in dry yards or at dehydrators rather than in the field, often under contract with the buyer. If a raisin grape crop is sold fresh, growers are paid on fresh ton weight and may or may not know whether their crop will be dehydrated. The season for the production of Golden Bleached (artificially dehydrated) raisins, the principal bleached type made, may run well into October.

Forecasts and estimates of total production of raisin-type grapes are made by the Federal-State Crop Reporting Service monthly beginning with July 1, terminating with the Fruit and Nut Crop Annual Summary in December. An estimate of the seasonal production of raisins based on industry opinion and a preliminary crop disposition check is first published in the Department's December Annual Crop Summary and is subject to revision the following June. For the years 1935 to 1949, the error in this preliminary estimate has ranged from 0.6 to 13.3 per cent and in 8 of the 15 years it was greater than 5 per cent. The revised estimate is based on available check data which are considered substantially complete. The Dried Fruit Association of California (D.F.A.C.) makes an estimate of raisin production which is published in the spring of the year following harvest at a time when most of the crop has been received by handlers. This estimate is also subject to revision one year later.

Sample Design

For all surveys during the three seasons, 1949, 1950, and 1951, estimates were based on information provided by a sample of units drawn in a random-stratified manner from a listing of all raisin grape units. Such a listing was available from records accumulated in the Crop Reporting Service periodic enumerative surveys of all fruit acreage by varieties in the state. A vineyard unit is considered in these records as a block of grapes consisting of one-tenth or more acres of a single variety. Usually, a unit will contain more than one variety of grapes. An individual may operate several units, and a single vineyard or farm may consist of more than one unit, although the single unit vineyard is most common. Stratification was by county and by bearing acreage of all raisin grape varieties in unit. Sampling units were allotted by strata for the 1949 preharvest survey on the basis of total number of units in stratum and the unit standard deviation of stratum bearing acreage. For later surveys, allocation was made in proportion to size of stratum and the sample standard deviation of stratum unit production of raisins. The project was on a trial basis in 1949 with sampling restricted to the four major producing counties of Fresno, Kings, Madera, and Tulare. Estimates of raisins made in other producing counties were obtained from members of the industry. This was not satisfactory from a research standpoint and in 1950 and 1951, units located in Kern, Merced, and Stanislaus counties were added to the sample, thus providing in the latter two seasons a complete coverage of the producing areas of sun-dried raisins made from the varieties samples--Thompson Seedless, Muscat, and Sultana.

The estimates and their (estimated) standard errors shown in Table 4 for 1950 and 1951, based on the 1951 survey data, were computed with reference to four broad acreage strata, as shown in the tabulation below, disregarding county breakdowns.

Reference Strata, 1951 Surveys

Strata	Bearing acres in units	Number of units in surveyed counties	Number of units in sample
		N_h	n_h
I	Below 40	10,067	578
II	40-99.9	780	140
III	100-399.9	161	60
IV	400 and over	8	8
	Total	11,016	786

The effective stratification comprised many more strata. Not only were units drawn from size strata of every county included in the survey, but the size strata were less broad. Within reference Strata I and II, sample units were drawn in a systematic random manner from size classes of 10 acres and, within Stratum III, largely from 25-acre classes (see Table 2). Standard errors computed on the basis of reference strata would, therefore, tend to overestimate somewhat the sampling variability of estimates. It should be noted that Stratum IV, consisting of only 8 units, was enumerated. Stratum III was enumerated in the 1950 surveys. In 1951 all of the units of this stratum were contacted for the final survey. It will be noted from the various entries in Table 4, which show for several items, estimates and their estimated standard errors separately for sampling and enumeration of Stratum III, that the enumeration of this stratum (which required the addition of some 100 units to the sample) had neither changed significantly the magnitudes of the estimates for 1951, nor materially decreased the (estimated) standard errors. The data shown in Table 7 for the within-season surveys are based on the finer size stratification as given in Table 2.

Several types of estimates of population totals are shown in Table 4:

1. Linear (stratified). This estimate is of the form

$$(1)\ T_L = \sum_h^R N_h \left(\sum_i^{n_h} X_{hi}/n_h\right)$$

in which X_{hi} is the value of some item for the ith unit in the sample drawn from stratum h, N_h is the total number of units, n_h is the number of units in the sample drawn from stratum h, and R, the number of strata. The variance of T_L is easily shown to be

$$(2)\ \sigma^2_{T_L} = \sum_h^R N_h^2 \sigma_h^2 (N_h - n_h)/n_h(N_h - 1)$$

in which σ_h^2 is the population variance in stratum h. An unbiased estimate of $\sigma^2_{T_L}$ is given by

$$(3)\ s^2_{T_L} = \sum_h^R N_h(N_h - n_h)s_h^2/n_h$$

with s_h^2 defined as

$$(4)\ s_h^2 = \sum_i^{n_h}(X_{hi} - \bar{X})^2/(n_h - 1)$$

The estimated standard errors of the linear estimates shown in Table 4 were calculated using expression (3).

TABLE 2

Frequency Distribution of Raisin Grape Units by Bearing Acreage
Seven Counties Surveyed--1950

Bearing acreage	Number of units in counties surveyed	Per cent of bearing acreage	Number of units in sample 1951 surveys
0.1- 9.9	3,620	9.1	
10- 19.9	4,024	27.0	
20- 29.9	1,411	14.9	
30- 39.9	1,012	15.9	
Reference stratum I	10,067	66.6	578
40- 49.9	285	5.5	
50- 59.9	190	4.7	
60- 69.9	116	3.4	
70- 79.9	111	3.7	
80- 89.9	53	2.1	
90- 99.9	24	1.2	
Reference stratum II	780	20.6	140
100-124.9	61	3.0	
125-149.9	38	2.2	
150-174.9	28	2.0	
175-199.9	6	0.5	
200-399.9	28	3.1	
Reference stratum III	161	10.8	60
Reference stratum IV (400 and over)	8	2.0	8
Total	11,016	100.0	786

Source: Fruit and Nut Acreage Enumerative Survey.

It is well known that, for equal (over strata) per-unit costs of measurement, a substantial reduction in the magnitude of $\sigma_{T_L}^2$ may be secured, provided strata variances, σ_h^2, vary widely by using the Neyman "optimum" allocation[1]

$$(5)\quad n_r^o = nN_r\sigma_r' \Big/ \sum_h^R N_h\sigma_h'$$

in which $\sigma_h' = \sigma_h\sqrt{N_h/(N_h - 1)}$. Experimental evidence provided by Sukhatme[2] also indicates that near optimum results may be secured by replacing the population standard deviations σ_h' in (5) by sample estimates s_h. The results cited in the tabulation below show that the actual sample sizes for the first three reference strata do not differ markedly from the near optimum sample numbers obtained using

$$(5a)\quad n_r' = nN_r s_r \Big/ \sum_h^R N_h s_h$$

for some of the important items of the final survey in 1951.

Estimated Optimum Allocations
(1951 Final Survey Data)

Reference strata	Optimum sample numbers for				1951 sample sizes
	Raisin production	Acreage harvested for raisins	Raisin grape production	Bearing acreage	
I	596	583	616	622	578
II	120	124	98	86	140
III	62	71	64	70	60
Total	778	778	778	778	778

2. Ratio (stratified). With stratification, two forms of the ratio estimate are possible

$$(6)\quad T_r^{(1)} = \sum_h^R \xi_h \bar{Y}_h/\bar{X}_h$$

and

$$(7)\quad T_r^{(2)} = \xi \sum_h^R N_h\bar{Y}_h \Big/ \sum_h^R N_h\bar{X}_h$$

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[1] Neyman, J. On the two different aspects of the representative method. J. Roy. Stat. Soc. 97:558-625, 1934.

[2] Sukhatme, P. V. Contributions to the theory of the representative method. J. Roy. Stat. Soc. 2:253-268 (Supplement), 1935.

in which $\overline{Y}_h$ is the current year sample mean in stratum h for some item, $\overline{X}_h$ the corresponding mean for the preceding year, ξ_h is the population total for the item in stratum h for preceding year, and ξ the over-all population total for preceding year ($\xi = \sum_h^R \xi_h$). Estimate $T_r^{(1)}$ is to be preferred if ratios differ substantially from stratum to stratum; however, its use presupposes knowledge of strata population totals, ξ_h. Since the latter is not known (except for bearing acreage, 1950), the second form of the ratio estimate was employed in all cases for which the ratio estimate was computed, X representing the 1950 and Y the 1951 data.

As is well known, the ratio estimate is biased unless the regression (of Y on X) is linear and through the origin.1/ The bias, however, is presumably negligible for large sample sizes. The mean square error of $T_r^{(2)}$, that is, $E(T^{(2)}-\eta)^2$, is given approximately by

$$(8)\quad \sum_h^R N_n(N_h - n_h)\, n_h^{-1}\, (\eta^2\sigma_{xh}^2/\xi^2 + \sigma_{yh}^2 - 2\sigma_{xh}\sigma_{yh}\,\rho_{xyh}\eta/\xi)$$

in which η is the current year population total (which is being estimated) and ρ_{xyh} is the population correlation coefficient between X and Y in stratum h. The estimated standard errors of the ratio estimates shown in Table 4 were obtained by substututing in (8) the sample equivalents of the population parameters η, ξ, σ^2_{xh}, σ^2_{yh}, and ρ_{xyh}.

3. Difference (stratified). This estimate, also linear, is of the form

$$(9)\quad T_d = \xi + \sum_h^R N_h(\overline{Y}_h - \overline{X}_h),$$

and is, obviously, unbiased. Its variance is

$$(10)\quad \sigma^2_{T_d} = \sum_h^R N_h^2(N_h - n_h)(\sigma^2_{xh} + \sigma^2_{yh} - 2\sigma_{xh}\sigma_{yh}\,\rho_{xyh})/n_h(N_h - 1).$$

An unbiased estimate of $\sigma^2_{T_d}$ is given by

$$(11)\quad s^2_{T_d} = \sum_h^R N_h(N_h - n_h)(s^2_{xh} + s^2_{yh} - 2s_{xyh})/n_h$$

1/ Cochran, W. G. Recent developments in sampling theory in the United States. International Statistical Institute. Proceedings of the International Statistical Conferences. September 6-18, 1947. Vol. III, Part A, pp. 40-66.

in which $s_{xyh} = \sum_{h}^{R}(X_{hi} - \bar{X}_h)Y_{hi}/(n_h - 1)$. The estimated standard errors of difference estimates shown in Table 4 were computed using (11).

Estimates of Bearing Acreage

Estimates of bearing acreage of raisin-type grapes (Thompson Seedless, Muscat, and Sultana) for 1950 and 1951 are shown in Table 4. Orchard records place the 1950 bearing acreage of these varieties in the seven surveyed counties at 217,748 acres as compared with the sample expansion of 215,417. The ratio of 1950 bearing acreage of Thompson Seedless, Muscat, and Sultana varieties of grapes in the state to that in the seven sample counties is 1.0558. Expanding the sample estimate by this factor and adding the 3,990 acres of Zante currant and other raisin varieties yields 231,427 acres as an estimate of the 1950 bearing acreage of all raisin-type grapes in the state. This indication compares favorably with the official estimate which is now placed at 233,888 bearing acres for 1950. It will be noted that the computed standard errors of the seven-county estimates of bearing acreage for 1950 and 1951 are a little over 2 per cent. However, the standard errors for Muscat and Sultana varieties are relatively much larger and, particularly for the latter, are so large as to make it inadvisable to prepare separate estimates for this variety without increasing substantially the size of the sample or changing radically the sample design.

Estimates of Acreage Harvested for Raisins

The relation between bearing acreage per unit and acreage harvested for raisins (natural dried and bleached) for 1951 is shown in Table 3. These data are intended to provide an indication of this relation for the population of raisin-type grape units which was sampled. Hence, the entries (percentage frequencies) in this two-way table have been adjusted for differences in sampling rates of reference Strata I and II (Stratum III was enumerated for the final survey which provided these data). Some interesting facts emerge from a consideration of this table. Almost 40 per cent of all raisin-type grape units did not produce raisins in 1951. Nonproducing units ranged in size from smallest to largest. Thus, 49 per cent of units containing 100 or more bearing acres and 46 per cent of units containing fewer than 10 bearing acres did not harvest for raisins in 1951. Of the units producing raisins, about 85 per cent produced to full capacity, that is, harvested all of the bearing acreage in their units for raisins.

Linear estimates of acreage harvested for naturally dried raisins in 1950 and 1951 are shown in Table 4. These estimates are subject to a relatively larger sampling error (about 4 per cent for 1951) than those of bearing acreage. Acreage harvested for natural raisins in 1951 was indicated to be about 14 per cent larger

TABLE 3

Bearing Acreage and Acreage Harvested for Raisins, Three Main Raisin Varieties,
Per Cent of Units in Specified Acreage Classes--
Seven Counties Surveyed, 1951

Acres harvested for raisins, 1951	Bearing acreage, 1951																		Total
	0.1-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-99.9	100-124.9	125-149.9	150-174.9	175-199.9	200-299.9	300-399.9	400-499.9	500 and over	
0	14.02	13.86	4.49	2.81	1.24	0.74	0.51	0.21	0.28	0.18	0.23	0.20	0.10	0.06	0.16	0.02	0.04	0.02	39.17
0.1- 9.9	16.60	2.20	0.83	0.15	0.16	0.06			0.06		0.02								20.08
10- 19.9		21.92	1.87	0.69	0.06	0.32	0.06	0.01	0.06										24.99
20- 29.9			5.91	0.84	0.26	0.06	0.10	0.06			0.01								7.24
30- 39.9				4.43	0.38	0.22		0.11			0.01	0.02		0.01					5.18
40- 49.9					0.78	0.06	0.01	0.11	0.01		0.02	0.02	0.01		0.01				1.03
50- 59.9						0.77	0.01			0.01	0.01		0.01	0.01					0.82
60- 69.9							0.19		0.06		0.02	0.01				0.02			0.30
70- 79.9								0.44			0.08								0.52
80- 89.9									0.07		0.08	0.01							0.16
90- 99.9										0.02	0.02								0.04
100-124.9											0.20	0.01	0.02		0.01				0.24
125-149.9												0.03	0.01		0.02				0.06
150-174.9													0.07		0.01				0.08
175-199.0														0.02		0.01			0.03
200-299.0															0.02				0.02
300-399.9																0.02			0.02
400-499.9																	0.01	0.01	0.02
Total	30.62	37.98	13.10	8.92	2.88	2.23	0.88	0.94	0.54	0.21	0.70	0.30	0.22	0.10	0.23	0.07	0.05	0.03	100.00

NOTE: Percentage frequencies are adjusted for differences in sampling rates of reference strata.

TABLE 4

Acreage and Production Estimates, 1950 and 1951; Raisin Grapes and Natural Raisins, Three Main Varieties
Seven Counties Surveyed, 1951

Type of estimate	1950					1951				
				Total					Total	
	Thompson Seedless	Muscat	Sultana	Point estimate	95 per cent confidence interval	Thompson Seedless	Muscat	Sultana	Point estimate	95 per cent confidence interval
	I. Bearing Acreage									
	acres									
1. Linear	173,663 (4,274)	38,624 (2,773)	3,130 (506)	215,417 (4,437)	206,720- 224,114	172,480 (4,315)	36,361 (2,754)	3,042 (503)	211,883 (4,534)	202,996- 220,770
2. Linear, stratum III enumerated						173,614 (4,138)	34,483 (2,447)	3,048 (500)	211,145 (4,372)	202,576- 219,714
	II. Acreage Harvested for Natural Raisins									
	acres									
1. Linear	86,214	4,538	984	91,736 (4,207)	83,490- 99,982	98,353 (4,197)	5,225 (1,001)	1,318 (320)	104,896 (4,581)	96,309- 113,483
2. Linear, stratum III enumerated						97,583 (4,022)	5,153 (998)	1,318 (320)	104,054 (4,211)	95,800- 112,308
	III. Preharvest Production Forecast, August, 1951									
	tons, fresh weight									
1. Linear						1,292,574	220,246	16,250	1,529,070 (38,782)	1,453,057- 1,605,083

(Continued on next page.)

Table 4 continued.

Type of estimate	1950					1951				
				Total					Total	
	Thompson Seedless	Muscat	Sultana	Point estimate	95 per cent confidence interval	Thompson Seedless	Muscat	Sultana	Point estimate	95 per cent confidence interval
	IV. Total Production									
	tons, fresh weight									
1. Linear	1,104,719	171,585	14,398	1,290,702 (33,772)	1,224,509- 1,356,895	1,445,083 (41,537)	223,857 (18,442)	20,060 (3,276)	1,689,000 (42,702)	1,605,304- 1,772,696
2. Linear, stratum III enumerated						1,452,322 (40,437)	210,674 (16,367)	19,500 (3,203)	1,682,496 (41,436)	1,601,281- 1,763,711
3. Ratio									1,638,007 (20,031)	1,598,746- 1,677,268
4. Difference									1,687,485 (19,598)	1,649,073- 1,725,897
	V. Production of Natural Raisins									
	tons, dried weight									
1. Linear	130,149	4,166	1,274	135,589 (6,689)	122,479- 148,699	196,319 (8,929)	6,906 (1,345)	2,252 (564)	205,477 (9,103)	187,635- 223,319
2. Linear, stratum III enumerated						195,138 (8,661)	6,837 (1,342)	2,252 (564)	204,227 (8,839)	186,385- 222,069
3. Ratio									203,914 (6,129)	191,901- 215,927
4. Difference									204,446 (5,469)	193,727- 215,165

NOTE: Numbers in brackets are estimated standard errors of corresponding estimates. Expansions for 1950 are based on preharvest survey data obtained in August, 1951. All expansions for 1951, except preharvest forecast of production, are based on final survey data obtained in September and October, 1951.

than that in 1950. The comparable increase in production of natural raisins was about 52 per cent as shown by other data in Table 4 and about 64 per cent as shown by current production check data. This suggests that increased yield rather than increased acreage is primarily responsible for the large increase in production of raisins in 1951. Sample data indicate, in fact, that yield increased by about one-third. The linear estimates of acreage harvested for all raisins (naturally dried and bleached) are 98,950 (4,226) acres for 1950 and 108,136 (4,334) acres for 1951. The figures in brackets following the estimates are estimated standard errors. Since the final disposition of a crop purchased outright in fresh form from the grower may not be known to the latter, estimates of total acreage harvested for raisins are subject to a downward bias. Indications are that bleached production in 1951 was underestimated from the sample by about 60 per cent. The linear estimate of acreage harvested for bleached production was about 3,400 for 1951. Thus, the relative magnitude of the downward bias in the estimate of total acreage harvested for raisins is apt to be between 4 and 5 per cent.

Acreage Intentions

The preharvest survey in 1951 included a question on acreage expected to be harvested for raisins during the 1951 season. Table 5 shows the relation between acreage intentions for 1951 and acreage actually harvested for raisins in 1951. As in Table 3, the percentage frequencies were adjusted for differences in sampling rate of the reference strata. The slight differences in the marginal frequencies of harvested acreage in Tables 3 and 5 are accounted for by the fact that Stratum III was not enumerated in the preharvest survey so that, unlike Table 3, the rate at which Stratum III was sampled had to be taken account of in the construction of Table 5. It will be noted that for almost 25 per cent of raisin-type units, harvest intentions were not definite enough to be specified numerically at the time of the preharvest survey. For other units, the agreement between harvest intentions and harvest performance appears to be quite good. On the assumption that an entry in a diagonal cell of Table 5 indicates equality of intentions and performance, Table 5 shows that for approximately 86 per cent of respondent units, the agreement between intentions and harvest performance was exact. Similar impression is derived from Table 6 in which it is possible to compare by reference strata the acres intended to harvest and the acres actually harvested per respondent units. The agreement between these averages is excellent.

Table 6 also makes it possible to compare, by reference strata, the harvest performance per unit, for both 1950 and 1951, of the 1951 units with uncertain intentions (hereafter termed D.K. units) and the remainder of the sample. For both seasons, acreage harvested for raisins per unit was substantially smaller for D. K.

TABLE 5

Acreage Intentions and Acreage Harvested for Raisins, Three Main Raisin Varieties; Per Cent of Units in Specified Acreage Classes-- Seven Counties Surveyed, 1951

Acreage harvested for raisins, 1951	Acreage intentions, 1951																			Total
	Un-certain	0	0.1-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-99.9	100-124.9	125-149.9	150-174.9	175-199.9	200-299.9	300-399.9	400 499.9	
0	14.62	20.94	1.73	0.98	0.86		0.11													39.24
0.1- 9.9	3.68	1.18	13.75	1.00	0.36			0.05												20.02
10- 19.9	3.83	1.23	0.36	18.93	0.59		0.05													24.99
20- 29.9	1.42	0.18	0.09	0.25	5.21				0.05	0.05										7.23
30- 39.9	0.69	0.18		0.05	0.12	4.02	0.05	0.05												5.16
40- 49.9	0.05				0.03		0.85		0.03	0.05				0.03						1.04
50- 59.9	0.11						0.05	0.64												0.80
60- 69.9	0.05	0.05					0.03		0.15											0.28
70- 79.9	0.05									0.44										0.49
80- 89.9	0.03								0.05		0.08									0.16
90- 99.9												0.08								0.08
100-124.9									0.03		0.03	0.05	0.16							0.27
125-149.9							0.03							0.03						0.06
150-174.9															0.03					0.03
175-199.9															0.03		0.01			0.04
200-299.9																0.03	0.03			0.06
300-399.9																	0.03			0.03
400-499.9																		0.01	0.01	0.02
Total	24.53	23.76	15.93	21.19	7.17	4.02	1.17	0.74	0.31	0.54	0.11	0.13	0.16	0.06	0.06	0.03	0.07	0.01	0.01	100.00

NOTE: Percentage frequencies are adjusted for differences in sampling rates of reference strata.

TABLE 6

Bearing Acreage and Acreage Harvested for Raisins Respondents and D. K.'s, Seven Counties Surveyed, 1951 Preharvest and Final Surveys

Reference strata	1950		1951	
	Respondents	D. K.'s	Respondents	D. K. 's
	Bearing Acres Per Unit[a]			
I	15.4	14.7	15.3	14.7
II	56.0	54.7	54.8	52.8
III	157.8	116.4	158.9	115.8
	Acres Harvested for Raisin Per Unit[b]			
I	8.4	4.9	9.7	4.9
II	26.9	18.4	27.2	22.0
III	47.5	20.8	55.8	20.8
	Acres Intended to Harvest Per Unit[a]			
I			9.9	
II			28.9	
III			55.5	
	Per Cent of Bearing Acres Harvested for Raisins			
I	54.9	33.4	62.9	35.4
II	48.1	33.7	49.6	41.6
III	30.1	17.9	35.1	18.0

[a] Preharvest Survey, August, 1951.

[b] Final Survey, September-October, 1951.

units than for respondents. One possible explanation is that on the average the bearing acreage in D. K. units is smaller than among respondents, although some control over size of unit is imposed by the use of reference strata. Table 6 indicates that the average size of unit among respondents is slightly larger than for D.K. units in Reference Strata I and II and substantially so in Stratum III. These differences, however, are not large enough to account for the markedly larger acreage harvested for raisins by respondents. Differences between percentages of bearing acreage harvested for raisins in the two groups of units parallel, in fact, the differences in means. The inference seems unavoidable, at least with reference to 1951 data, that operators responding as uncertain to questions regarding intentions will on the average allocate a smaller acreage to production of raisins than operators whose preseason plans are definite.

Production of Raisin-Type Grapes

Linear, ratio, and difference estimates of 1951 total production of raisin-type grapes in the seven surveyed counties together with estimated standard errors are shown in Table 4. It will be noted that the standard errors of both the ratio and difference estimates are about half the standard errors of linear estimates, even with Stratum III enumerated for the latter, but not the former. The standard errors are relatively quite small, amounting in the case of linear estimates to about 2.5 per cent and in the case of ratio and difference estimates to about 1.2 per cent. Linear estimate for 1950 is also shown in this table. Multiplying this estimate by 1.0741, the ratio of 1950 bearing acreage of all varieties of raisin-type grapes in the state to the bearing acreage of the three varieties sampled in the seven surveyed counties gives approximately 1,386,000 tons fresh weight as an estimate of the state production of raisin-type grapes. This estimate compares favorably with the latest check figure of 1,326,000 tons for 1950 as given in the 1951 December California Fruit and Nut Annual Summary. Applying the same expansion factor to the 1951 sample estimate gives an indication of 1,814,000 tons which can be compared with the current official estimate of 1,805,000 tons.[1] Official estimates of production by varieties are not made.

In the preharvest survey, the operators were also asked to indicate the production of raisin-type grapes expected on their units in 1951. As can be seen from

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1/ This expansion method assumes that the yield per acre in the counties surveyed is the same as in the nonsurveyed counties and that the yield of nonsurveyed varieties is the same as of the varieties surveyed. Data from other grape samples obtained at the same time as the raisin production survey data indicate a lower yield in the latter counties.

Table 4, the linear estimate of expected total production is almost 10 per cent lower than the production estimate secured in the final survey. When expanded, as above, to a state total, it was 1.1 per cent below the September 1 official estimate. There is little reason to question the significance of the difference between the preharvest and final estimate. As the tabulation below indicates, production was underestimated in the preharvest survey in each of the reference strata.

Expected and Realized Production of Raisin-Type Grapes

Reference strata	Expected production	Realized production
	tons, fresh weight, per reporting unit	
I	112	125
II	396	420
III	1,075	1,187
IV	3,774	4,076

Production of Raisins

Estimates of production of raisins shown in Table 4 for 1950 and 1951 refer to naturally dried raisins. As in the case of total production, the ratio and difference estimates have substantially smaller standard errors than the corresponding linear expansions. The apparent superiority of ratio and difference estimates is maintained even if the standard errors of the linear estimates (but not of the ratio and difference estimates) are recalculated using a stratification more nearly resembling that actually employed in drawing the sample. Thus, the standard error of linear estimate of natural raisin production in 1950, using the finer size stratification of Table 2, is 6,329 tons as compared with a standard error of 6,689 tons computed on the basis of reference strata (see Table 4). This reduction is rather trivial in view of the increase in the number of strata from 3 to 15.

Linear estimates of artificially dehydrated production using the 1951 survey data are 10,734 tons (dried weight) for the 1950 season and 7,417 tons for 1951. Check data indicate bleached production of 17,758 tons for 1950. The latest available figures on deliveries in 1951 sum to 18,060 tons (Raisin Administrative Committee Seasonal Deliveries through August 2, 1952). Thus, for both seasons, 1951 survey indications very substantially underestimate bleached raisin production. Estimation of the latter was not an objective of the raisin production surveys and the cited indications are an incidental by-product. Estimates of bleached raisin

production published in the reports of the raisin production surveys for 1949, 1950, and 1951 were obtained from separate enumerations of production in dehydrator plants and dry yards.

How accurate have been the survey estimates of natural raisin production? The estimate for the 1949 season was based on a survey of only four counties and, thus, a direct comparison with check data is not possible. However, the 1950 preharvest survey linear expansion for natural raisins produced in 1949 of the three varieties surveyed was 234,164 tons compared with the currently checked production estimate of 235,376 tons. The latest available check figure on 1950 natural raisin production is 134,665 tons dried weight which represents deliveries to handlers to July 5, 1952. The linear estimate based on 1951 survey data is 135,589 tons (see Table 4) and is within 1 per cent of the check figure. Further comparisons based on various estimates from the October, 1950, final survey, estimate released on October 19, 1950, and their difference in per cent from check data now available are as follows:

Type of expansion	Estimates of production of natural raisins, 1950		Differences	
	Thompson Seedless	Total[a]	Thompson Seedless	Total[a]
	dried tons		per cent	
Linear	122,111	127,776	-4.3	-5.1
Ratio[b]	124,713	130,461	-2.3	-3.1
Ratio, revised[b][c]	123,324	128,936	-3.4	-4.2
Survey estimate as published[d]	125,000	130,700	-2.1	-2.9
Recorded deliveries[e] to July 5, 1952	127,654	134,557	0	0

[a] Includes Thompson Seedless, Muscat, and Sultana varieties.

[b] Computed using ratios of sample indications of production of natural raisins in 1950 to 1949 weighted by estimated 1949 production within reference strata.

[c] Based on revised estimate of production for 1949.

[d] October 19, 1950.

[e] Raisin Administrative Committee, Weekly Report of Deliveries to Handlers.

Present indications are that the October final survey estimates for the 1951 season are not quite as satisfactory as those above for 1950. Seasonal deliveries through July 5, 1952, of natural Thompson Seedless, Muscat, and Sultana varieties as reported by the Raisin Advisory Committee amount to 220,493 tons. Thus, the highest estimate for 1951 shown in Table 4 is about 7 per cent and the published survey estimate of 209,600 tons (October 10, 1951) about 5 per cent low. Of some interest also is a comparison of the published estimate based on the October sample and the estimate common in the trade at about the time the former was released. This is shown below. It should be added that a measure is not available at present of the accuracy of the check data used in appraising the 1950 and 1951 sample estimates. The check data are still subject to revision for both years but even in final form may not be completely accurate. Figures on seasonal deliveries are based on reports from a score or more firms, all of which may or may not have the exact data available at the time required or be able to distinguish receipts by crop years in which produced.

Comparison of Estimates of Production of Natural Raisins From Thompson Seedless, Muscat, and Sultana Variety Grapes

Season	Published survey estimate[a]	Estimate common in trade[b]	Present check data indication[c]	Per cent difference	
				Survey	Trade
	dried tons				
1949	226,300	259,000	235,576	-3.9	9.9
1950	130,700	135,000	134,665	-2.9	0.2
1951	209,600	235,100	220,493	-4.9	6.6

a/ California Crop and Livestock Reporting Service, Dried Raisin Production Survey (November 3, 1949); Estimated Raisin Production--1950 (October 19, 1950); Estimated Raisin Production--1951 (October 10, 1951).

b/ California Fruit News, November 5, 1949 (p. 6); October 14, 1950 (p. 6); October 6, 1951 (p. 6).

c/ Raisin Administrative Committee. Weekly Report of Deliveries to Handlers. The check figures shown for 1950 and 1951 represent seasonal deliveries (sweatbox weight) through July 5, 1952 of natural Thompson Seedless, Muscat, and Sultana raisins.

Within-Season Estimates

The primary objectives of the two within-season surveys was to provide information on prospective tonnage of natural raisins and acreage being harvested for raisins to specified dates while harvest was in progress. The two surveys made each season were one week apart. In 1951 reports were issued within 3 days of the starting date of each survey. In order to reduce costs, one-half of the regular sample of raisin-type grape units was utilized for each of the within-season surveys; odd-numbered units provided the sample for the first survey and even-numbered units were used in the second survey. In addition to tonnage of natural raisins expected from grapes on trays and acreage harvested for production of natural raisins, information was also obtained from operators on the acreage harvested for all purposes, acreage expected to be harvested for production of all types of raisins during the season, and the number of trays harvested.

Linear acreage and production estimates based on the information collected in the within-season surveys are shown in Table 7. Estimates of 1951 bearing acreage, acreage harvested for natural raisins in 1950, and production of natural raisins in 1950 are also cited as control items. As was indicated previously, the estimates shown in this table and the accompanying standard errors were computed using the detailed size stratification of Table 2. It will be noted that the standard errors of within-season estimates are roughly of the same order of magnitude as the standard errors of comparable estimates calculated on the basis of reference strata utilizing the full sample (as shown in Table 4). In relative terms, however, the standard errors of the within-season estimates are rather substantial, particularly for the first within-season survey. Thus, the relative standard error of acreage harvested for natural raisins is over 8 per cent (of the estimate) for the first within-season survey and about 9 per cent for trays harvested and expected tons of raisins.

As stated, information on production of raisins to specified date was obtained in these surveys in terms of number of trays harvested and tonnage of raisins expected by operators from grapes thus harvested. Neither item yields objectively the tonnage of raisins produced. Objective information on production in dried tons, in fact, cannot be obtained until harvest is completed and most of the raisins are delivered to handlers. However, these items are of some help in indicating approximately the tonnage being harvested. It is of some interest to note that using the customary 5.5 pounds of raisins per tray to convert trays into tons of raisins gives consistently higher estimates of tonnage than production figures obtained directly from operators (113,500 as compared with 108,100 tons for the first survey and 192,600 as against 185,500 tons for the second survey).

TABLE 7

Within-Season Acreage and Production Estimates, Raisin-Type Grapes and Natural Raisins, Seven Counties Surveyed, 1951

Type of estimate	Acreage harvested for natural raisins	Total trays harvested[a]	Tons of natural raisins expected from grapes harvested	Total acreage of raisin grapes harvested	Acreage expected to harvest for raisins	1951 bearing acreage	Acres harvested for natural raisins, 1950	Production of natural raisins, 1950
	1	2	3	4	5	6	7	8
	acres	1,000 trays	tons, dried weight	acres				tons, dried weight
	First Within-Season Survey, September 4							
Linear estimate	58,829	41,285	108,135	78,812	111,928	213,545	91,821	135,455
Estimated standard error	4,839	3,698	9,524	5,050	6,108	3,513	5,909	9,480
	Second Within-Season Survey, September 11							
Linear estimate	93,362	70,040	135,482	117,206	111,569	216,091	96,586	140,303
Estimated standard error	5,258	4,297	11,431	5,324	5,914	3,527	5,555	8,804

a/ At 5.5 pounds of raisins per tray, these estimates correspond to the following dried weight tonnages of natural raisins: 113,534 (10,170) and 192,610 (11,817).

Production of natural raisins to specified date may also be estimated by relating sample indications of number of trays or tonnage harvested to total production of natural raisins in the preceding season. Such ratio estimates based on reference acreage strata (computed using formula (7)) and their estimated standard errors are shown in the tabulation below for the two within-season surveys in 1951. These estimates are somewhat lower than the corresponding linear expansions shown in Table 7, particularly for the second within-season survey, and have also somewhat lower but still relatively large standard errors.

Ratio Estimates of Natural Raisin Tonnage
Expected from Grapes Harvested to Specified Dates, 1951

Item	First within-season, September 4	Second within-season, September 11
	tons, dried weight	
Tonnage from trays harvested[a]	112,775	183,611
Estimated[a] Standard error	9,058	9,803
Tonnage expected by operators	107,810	177,871
Estimated Standard error	7,806	9,552

[a] Reduced to tons at 5.5 pounds of raisins per tray. In units of 1,000 trays these estimates and their standard errors are 41,009 (3,294) and 66,768 (3,565).

Survey Costs

The table below presents estimates of average miles of travel, average interview time (including time of travel), mileage cost, and total field cost per completed schedule for the 1951 surveys. The latter average comprises all payments to enumerators for time ($1.47 per hour) and mileage (graded from 5 to 7 cents per mile in calendar month). The average time and mileage cost for all surveys in 1951 was $1.82 per schedule; analogous average costs for 1949 and 1950 were respectively $2.38 and $1.73. The relatively high average for 1949 can be attributed in part to the fact that fewer enumerators were employed who resided in the locality of their work and in part to the unavoidably higher expenditures incurred in the location of sample units for the 1949 preharvest survey. The 1950 and 1951 samples in the four main producing counties consisted very largely of the 1949 sample units and, hence, these location costs were not reincurred in later surveys. Higher time

and mileage compensation rates in 1951 account for the somewhat higher average field cost in 1951 as compared with 1950. The total costs of the four raisin production surveys varied from about $5,800 to $7,900 in the three years in which they were made.

Enumerator Time, Mileage, and Cost Estimates
Raisin Production Surveys--California, 1951

Survey	Number of interviews	Per interview completed			
		Miles traveled	Time in minutes[a]	Mileage cost	Time and mileage cost
Preharvest	778	9.6	58	$0.64	$2.05
First within-season	389	9.2	49	$0.61	$1.80
Second within-season	389	8.3	50	$0.55	$1.77
Final	551[b]	7.7	42	$0.51	$1.52
All					$1.82

a/ Includes travel time.

b/ Satisfactory schedule returned by mail by 227 units.

Discussion

In appraising the experience accumulated in the raisin production surveys separate, but of necessity brief, consideration will be given to questions of sample design on the one hand and measurement problems on the other. Discussion under the first heading will be restricted largely to an appraisal of the efficiency of the stratification procedure employed. Under the rubric "errors of measurement" will be considered the validity of basing acreage and production estimates on responses elicited directly from operators rather than on objective but more costly sample measurements and counts of acreage and crop. Problems of measurement will be considered first since, in a sense, these are prior to and more basic than particulars of sample design.

Errors of Measurement. The schedules used in the various surveys were brief (see Appendix) and the information requested from operators was of a direct and relatively simple character. Apart from questions dealing with intentions (acreage to be harvested for the production of raisins) and expectations (preharvest production expectations and tonnage of grapes expected from grapes harvested), the schedules referred to factual material. However, for the current year "factual" questions, the operator, in most instances, was not himself in possession of precise information and at best could report only what to him appeared to be a

reasonable approximation. This observation applies perhaps with greater force to production data than to acreage since the magnitude of the latter (e.g., acres harvested for production of natural raisins) is directly ascertainable by the operator. Ordinarily, only a small proportion of the raisin crop is delivered to handlers by October 13, the latest closing date of a final survey in the past three years. In most cases, therefore, the operator's response to questions in final survey on tons of raisins produced is inferential rather than directly factual, based as it is on approximate translation into tons of numbers of sweatboxes, field boxes, or other raisin containers. The same argument applies pari passu to operator's responses regarding total production (in fresh tons) of raisin-type grapes although in cases of harvest completed by the time of the final survey for uses other than the production of raisins, the fresh tonnage disposed through commercial channels may be known directly to the operator. On the other hand, in a small proportion of units the crop may not even have been harvested by the time of the final survey.

Response errors will naturally contribute to the total error to which estimates are subject. In addition, response errors may introduce a measurement bias. There are indications that estimates of production of natural raisins based on operator responses secured in the final surveys are, in fact, subject in some years at least to a downward response bias. This evidence will now be briefly reviewed.

Information concerning production of natural raisins on sample units during the preceding season was secured from operators interviewed in the 1950 and 1951 preharvest surveys. It is, therefore, possible to compare, for identical units, production indications obtained in the final survey, at the time the actual weight of raisins produced was still not available to the majority of operators, with production figures provided some 11 months later, presumably based on all objective information regarding quantity produced which could possibly be known to the operator. Averages (per unit) for such comparisons are shown in Table 8 separately for the 1949 and 1950 seasons by reference strata. For the 1949 season, the differences in production reported in the 1949 final and the 1950 preharvest surveys, are, on the average, small and not consistent over strata. For the 1950 season the average differences are more substantial and are of the same sign in all strata. On the average, the 1950 production of natural raisins was underreported in the 1950 final survey by some 8 per cent in comparison with the 1951 survey. The analogous figure for 1949 is about 2 per cent. A further fact of interest is that underreporting in the 1950 final survey was not independent of the quantity of raisins produced on the unit. The data shown in Table 9 indicate that, on the average,

TABLE 8

Comparison of Production of Natural Raisins Reported for Identical Units in Season Final and Subsequent Season Preharvest Surveys, 1949 and 1950 Seasons

Reference strata	Number of units	Reported production of natural raisins per unit		Final as per cent of preharvest
		Current final	Subsequent preharvest	
		tons		
1949 season[a]				
I	424	17.5	18.1	96.7
II	100	62.1	61.1	101.6
III	49	111.2	112.4	98.9
IV	4	483.5	479.9	100.8
All[b]		22.4	22.9	97.8
1950 season				
I	502	8.9	9.7	91.8
II	115	35.3	37.8	93.4
III	60	57.4	63.6	90.3
IV	8	181.2	193.3	93.7
All[b]		11.6	12.6	92.1

[a] Sample units located in Fresno, Kings, Madera, and Tulare counties.

[b] Weighted averages of stratum means; weights used are numbers of raisin-type grape units within the four acreage strata in seven surveyed counties.

TABLE 9

Average Differences in Production Reports and Variances of These Differences Related to Quantity of Natural Raisins Produced, 1950 Season

Reported production of natural raisins[a]	Number of units	Mean difference in production reports[b]	Variance of differences
tons		tons per unit	
0	351	+ 0.3	7.1
0.1- 9.9	73	- 0.2	3.4
10 - 19.9	66	- 0.3	23.9
20 - 29.9	58	- 2.0	39.7
30 - 39.9	44	- 3.7	93.4
40 - 49.9	21	- 6.1	114.1
50 - 69.9	21	-10.6	274.7
70 - 99.9	15	+ 2.9	66.3
100 -199.9	26	-10.7	735.9
200 -699.9	10	-24.9	2,240.1

a/ Based on reports in 1951 preharvest survey.

b/ Production of natural raisins reported in 1950 final survey minus production for identical units as reported in the 1951 preharvest survey.

underreporting was greater in absolute amount for units producing substantial quantities of raisins than for smaller units.

The standard of comparison used above is admittedly not perfect since responses of operators regarding preceding year's production are subject to memory bias and distortion; actual crop weights as shown, for example, on weight tickets would provide more satisfactory check data. Nevertheless, these comparisons are fairly indicative of a major source of error to which estimates of natural raisin production prepared at the end of the production (but not the marketing period) are liable. Such errors cannot be controlled by increasing the size of the sample. Given that raisin production estimates have to be prepared late in September or early in October, it would appear that the only possibility of controlling effectively response errors lies in the introduction of some objective measurements such as weights and counts of raisin containers as an integral part of the measurement procedure. This will increase substantially the cost of the final survey. Only further investigation can determine whether a final survey procedure based wholly or in part on objective measurements is at all feasible under a realistic budget.

Efficiency of Stratification. It is generally agreed that a listing intended to be an exhaustive census of a large class of elements can seldom be entirely complete, entirely accurate, and wholly up to date. In using an existing list as a frame from which to sample a definite hazard must be accepted of not being able to sample elements which are in the population intended to be sampled but not in the frame and of having to sample and include in various counts and expansion factors fictitious elements still in the listing, but no longer in the population. Yet, if a listing exists which is reasonably complete and accurate, sampling directly from such a list offers advantages which frequently more than compensate for the difficulties that may be encountered. In agriculture, a listing of elements (if it exists) is ordinarily more than just a bare enumeration of units. The listing provides some information concerning the population to be sampled, data which might enable an efficient use of devices such as stratification to reduce substantially the sampling variability of estimates. It should be added that, if the accuracy of expansion factors as derived from the listing is seriously in doubt, estimates may sometimes be employed which depend less directly on these factors.

The listing of grape units, revised annually, which served as the frame for the raisin production surveys, provided for each unit the acreage in grapes by varieties. In particular, for raisin-type grapes, the listing indicated for each unit the bearing acreage of Thompson Seedless, Muscat, and Sultana varieties. It

will be recalled that bearing acreage of the three major raisin grape varieties was used as a stratifying variable. One would expect that stratification on the basis of bearing acreage would be efficient for the estimation of total production of raisin-type grapes, but not necessarily so for the estimation of raisin production. As is evident from Table 3, many units (an estimated 40 per cent of units in 1951) do not produce raisins, and for units producing raisins, acreage harvested for raisins is far from perfectly correlated with total bearing acreage of raisin-type grapes.

Some indication of the efficiency of stratification may be obtained by comparing the (estimated) sampling variance of estimates provided by the stratified design with analogous (estimated) variance appropriate for unrestricted sampling. It is easily shown that an unbiased estimate of the over-all variance derived from data of a stratified sample is given by

$$\hat{s}^2 = \frac{1}{N} \sum_{h}^{R} N_h (s_h^2 + (\bar{X}_h - \bar{X}')^2) - \frac{1}{N^2} \sum_{h}^{R} N_h s_h^2 (N - N_h + n_n)/n_h$$

in which

$$\bar{X}' = \sum_{h}^{R} N_h \bar{X}_h / N$$

and the other symbols are as defined previously. A measure of relative precision of stratified as compared with unrestricted sampling is given for linear expansion by the ratio

$$\hat{s}_h^2 \, N(N - n)/n \sum_{h}^{R} N_h^2 \, s_h^2 (n_h^{-1} - N_h^{-1})$$

which also supplies an approximate indication of the factor by which sample size must be increased if unrestricted sampling is to provide estimates matching the sampling accuracy of stratified data.

This factor is shown in the tabulation below for four linear expansions based on the 1951 final survey. As was expected, the efficiency of stratification appears to be considerably greater for items pertaining to grapes than to raisins. Nevertheless, gains from stratification for all linear expansions are considerable. The smallest gain is obtained in the estimation of production of natural raisins. Even in this case, calculations show that an unrestrictedly drawn sample of some 1,323 units would be needed to match the sampling accuracy of a stratified sample of 778 units. These remarks apply only to linear expansions. For other types of estimates shown in Table 4, gains from stratification, if any, are likely to be more moderate.

Efficiency of Stratification (Reference Strata I-III)
Linear Expansions, 1951 Final Survey

Item	Estimated sampling variance[a]		Relative precision
	Unrestricted	Stratified	
Bearing acreage	84.1	20.6	4.1
Acreage harvested for natural raisins	37.1	19.2	1.9
Production of raisin-type grapes	5630	1823	3.1
Production of natural raisins	142.7	82.9	1.7

a/ Entries should be multiplied by 10^6 to obtain actual magnitudes.

APPENDIX

Schedules of the 1951 Raisin Production Surveys

I. Preharvest Survey Schedule

California Crop and Livestock Reporting Service
P. O. Box 1258, Sacramento 6, Calif.
1951 Raisin Grape Preharvest Survey

No._____

____
(Name of Operator) (Street, Route, Box) (City) (County) (Note Corrections)

Phone No.__________________

Location of Vineyard Unit: Sec.____: Twp.____: Range____: By Roads:________________
(Correct if necessary)

	Thompson	Muscat	Sultana
1. Bearing acres of raisin grapes in unit in 1950	___Acres	___Acres	___Acres
2. Acres harvested for raisins in 1950.	___Acres	___Acres	___Acres
3. Tons of natural raisins produced in 1950 from unit	Dry ___tons	Dry ___tons	Dry ___tons
4. Additional bleached tons produced in 1950 from unit	___ "	___ "	___ "
5. Bearing acres of raisin grapes in unit, 1951	___Acres	___Acres	___Acres
6. As of today how many of the above bearing acres do you intend to harvest for raisins this year? . . .	___Acres	___Acres	___Acres
7. Estimated total production of grapes on this unit:			
a) in fresh tons in 1951	Fr. ___tons	Fr. ___tons	Fr. ___tons
b) in fresh tons in 1950	___ "	___ "	___ "

8. Has harvest of this unit been completed for this season or have all the vines been girdled so that no raisins will be produced this year?

Interview made by ____________Date: August ____, 1951

(Put comments on back)

II. Within-Season Surveys Schedule

Raisin Grape Production Survey
September, 1951

Please answer the questions below only for the vineyard unit you operate located in Range ___________, Twp. __________________ and Section __________________ on which there are the following bearing acres of raisin variety grapes:

Thompson S. _____, Muscat_____, Sultana_____

Your answers to the first four questions below should relate to raisin grapes harvested to the close of

____

Please answer every question; enter "0" or "none" where it applies.

Do not include in this report information about other varieties of dried grapes.

(Report for each variety in columns indicated)

	Thompson S.	Muscat	Sultana
1. Total acres of raisin grapes harvested through above date for raisins, fresh shipment, or crushing. . .	acres	acres	acres
2. Acres of grapes harvested for natural raisins only this season through above date	acres	acres	acres
3. Total number of trays harvested through above date	trays	trays	trays
4. Estimated number of tons of natural raisins expected from grapes harvested through above date. . .	dry tons	dry tons	dry tons
5. Total acres of raisin grapes you expect to harvest for all types of raisins this season.	acres	acres	acres

Reported by: ______________________________

Date: September ____________, 1951

III. Final Survey Schedule

California Crop and Livestock Reporting Service
P. O. Box 1258, Sacramento, California

Final Raisin Grape Production Survey
September, 1951

Name:______________________ Phone:________________

Address:____

Location:_______________________________________

Please obtain answer to the questions below only for the vineyard unit located in Range: __________, Twp:__________ Sect:__________ on which there are the following bearing acres of raisin variety grapes:

Thompson S.__________, Muscat_______, Sultana_______

Complete every question; enter "0" or "none" where it applies. Do not include in this report information about other varieties of dried grapes.

(Report for each variety in columns indicated)

	Thompson S.	Muscat	Sultana
1. Acres of grapes harvested for raisins during entire 1951 season	acres	acres	acres
2. Estimated number of tons of natural raisins produced in 1951 from the above acres harvested.	dry tons	dry tons	dry tons
3. How many additional tons (if any) of bleached raisins were made this season from above acreages harvested	dry tons	dry tons	dry tons
4. Please estimate the total production of grapes on this unit in 1951, in fresh tons	fr. tons	fr. tons	fr. tons

Enumerator:_____________________________________

Date: October____________________, 1951